

REPRODUCTIVE BEHAVIOR OF *EUARESTA BELLA* AND  
*E. FESTIVA* (DIPTERA: TEPHRITIDAE), POTENTIAL  
AGENTS FOR THE BIOLOGICAL CONTROL OF  
ADVENTIVE NORTH AMERICAN RAGWEEDS  
(*AMBROSIA* SPP.) IN EURASIA

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*Abstract.*—Larvae of *Euaresta bella* (Loew) and *E. festiva* (Loew) destroy seeds of *Ambrosia artemisiifolia* L. and *A. trifida* L., respectively; *E. bella* has been colonized in the USSR for ragweed control. The univoltine adults feed on honeydew and ragweed sap. In Maryland, *E. bella* adults reach peak abundance in mid-August, *E. festiva* a month later. Courtship behavior by both sexes is complex, involving several stereotyped wing movements, proboscis and foot contact, head butting, and male territoriality or lekking. Oviposition occurs in the young female flowers.

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#### Introduction

The native North American ragweeds, *Ambrosia artemisiifolia* L., *A. trifida* L. and *A. psilostachya* DC., have become accidentally established in Eurasia, where they cause increasing agricultural and medical problems (Goeden et al., 1974). *Ambrosia artemisiifolia* and *A. trifida* are abundant in the northeastern United States, producing about 90% of the hayfever-causing late summer pollen to which about 4% of the population is sensitive (Dickerson and Sweet, 1971). These rapidly growing annuals are among the most important weeds in row crops, pastures, ornamentals and small fruits in the United States (Danielson et al., 1965). *A. artemisiifolia* and *A. trifida* have become established and troublesome in the southwestern USSR (Shutova, 1970), which is climatically similar to the eastern United States. The study of the bionomics of insects that attack ragweed in the northeastern United States was initiated by the author in 1976, and several species were shipped to the USSR. These included 425 adult *Euaresta bella* (Loew), which were colonized in 1977 at Sochi (O. V. Kovalev, personal comm.).

*Euaresta bella* is a small univoltine tephritid that occurs throughout the United States on *A. artemisiifolia*, its sole host (Foote, 1965; Wasbauer, 1972). In Ohio adults are found from mid-June to late September; reproduction begins in August; the larvae develop and overwinter in the seeds, destroying 1-15%; and pupation occurs in spring (B. A. Foote, 1965; in litt. 1977). *Euaresta festiva* (Loew) is a larger univoltine species that attacks only *A. trifida* in the eastern and midwestern states. In Ohio adults appear

in July; larvae destroy 2–25% of the seeds, where they overwinter; and pupation occurs in spring (B. A. Foote, 1965; in litt., 1977). The seed-feeding habit of larvae of these two tephritids contrasts with that of the larvae of *Euarestoides acutangulus* (Thomson), which destroy the staminate flowers of *Ambrosia* spp. (Piper, 1976).

Field and cage observations of *Euaresta bella* and *E. festiva* were made between 1976 and 1978 at the USDA Agricultural Research Center, Beltsville, Maryland. Caged adult flies were kept in a rearing room at 16L:8D hr. photoperiod, at about 25°C, or were kept in a greenhouse at ambient day-length at about 27–30°C. They were provided with vigorous potted host plants, water droplets, and food (4:1 sucrose/autolyzed yeast extract in water). Individual flies lived as long as two weeks.

*E. bella* adults began to appear in the field at Beltsville in mid-July, the females at that time being noticeably slender, with translucent abdomens; at this time the host plants were not yet blooming. The adult population of this insect reached a maximum in mid-August, when the male and female flowers of *A. artemisiifolia* began to bloom, and abdomens of female flies at this time were swollen and opaque. The fly population subsequently declined rapidly as most ragweed plants set seed, although male flowers continued to produce abundant pollen. By the end of August, *E. bella* adults were scarce. However, *E. festiva* reached its peak abundance in mid-September on the later-blooming *A. trifida*.

Both *E. bella* and *E. festiva* were relatively most active and phototactic during the late afternoon. They flew poorly, *E. bella* hopping only a few centimeters from leaf to leaf; *E. festiva* flying erratically for one or two meters to adjacent plants. Dispersive ability of individual flies is apparently slight, as in *Urophora jaceana* (Hering), which did not cross a two meter wide cart track to host plants on the other side (Varley, 1946).

Adult *E. bella* and *E. festiva* often licked ragweed leaves. Additionally, *E. bella* licked dew, honeydew of aphids and leafhoppers, the foam of cercopterid larvae on ragweed stems, sap oozing from damaged leaves, and the sucrose-yeast-water mixture. A droplet of food sometimes was repeatedly regurgitated and reingested by both sexes, behavior resembling nectar-whipping by bees, which reduces the water content. Honeydew and dew are often eaten by other tephritids (Christenson and Foote, 1960; Bateman, 1972).

### Courtship and Territoriality

The courtship behavior of *E. bella* and *E. festiva* is variable and complex (Table 1), involving stereotyped movement of the conspicuously patterned wings, visual orientation, wing and abdomen vibration, proboscis and foot contact, head butting, and lekking or male territoriality. As in *Valentibulla*

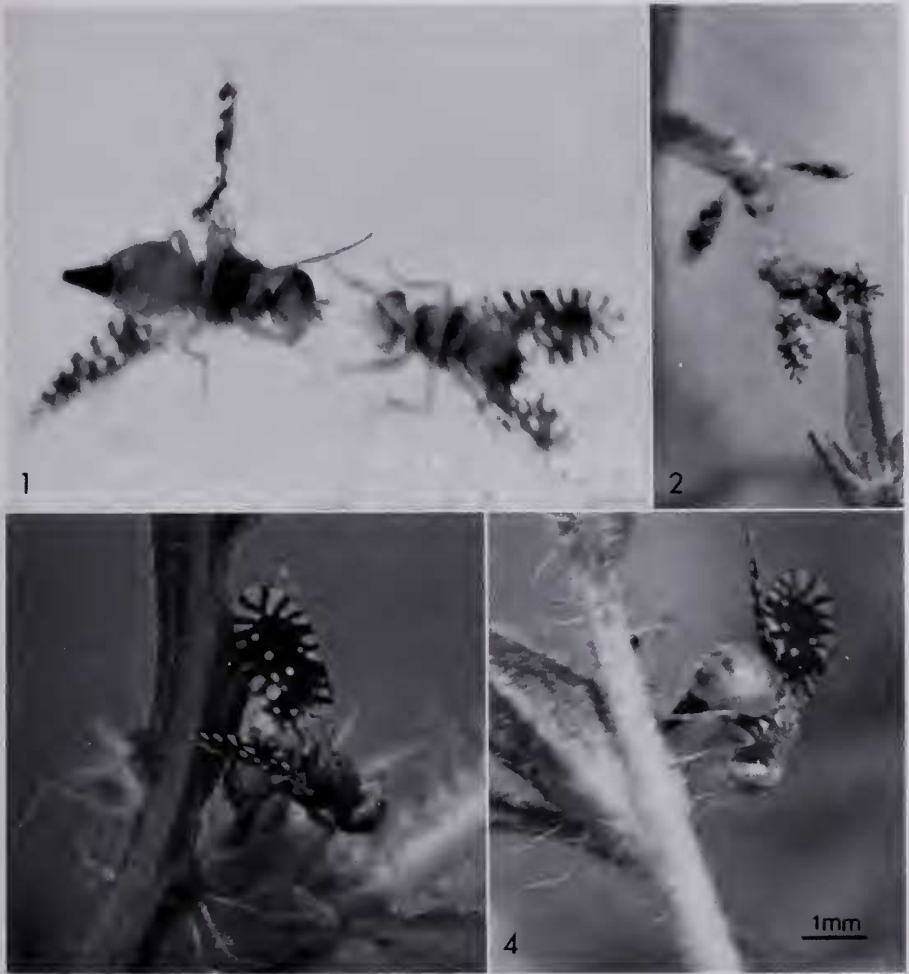
Table 1. Major courtship behavior patterns of *E. bella* and *E. festiva*. C, common, R, rare, —, not seen.

	<i>E. bella</i>		<i>E. festiva</i>	
	♂	♀	♂	♀
(1) Visual orientation	C	C	C	C
(2) Alternate wing waving with vibration	C	C	C	C
(3) Both wings extended horizontally	R	—	—	—
(4) Both wings extended with proboscis extended	C	C Front legs also extended	—	—
(5) Both wings extended with head butting	C	C	R	—
(6) Tapping with front feet	—	R	R	—
(7) Rapid flicks of both wings simultaneously	C	—	C With proboscis extension	—
(8) Territoriality (lekking)	C	—	C	—
(9) Following female, abdomen curved	R	—	C	—
(10) Following female, wings flattened against abdomen	—	—	C	—

(Wangberg, 1978), both sexes play active roles in courtship and the sequence of courtship displays is frequently interrupted and resumed at various stages.

Visual orientation by both sexes toward conspecific flies of both sexes (Table 1: item 1), and to other small insects was common. Orienting flies turned to face these insects as they moved about, and grooming was occasionally begun by flies that had been watching conspecifics or other insects that were grooming themselves. Orientation is common in many tephritids (Tauber and Toschi, 1965; Piper, 1976; Berube, 1978; Wangberg, 1978) and in *Drosophila* (Spieth, 1974).

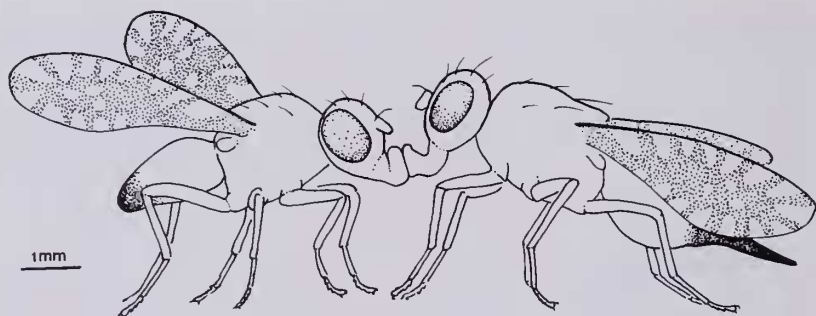
During orientation, random walking, and (in females) while mating, both species of *Euaresta* often slowly waved alternate wings. A slight vibration of the extended, vertical wing was sometimes seen, and side-stepping may occur (Table 1: 2). Occasionally an *E. bella* male or female faced another fly of either sex while waving alternate wings (Fig. 1); the other fly responded by synchronous ipsilateral wing waving. Similar behavior occurs in *Euarestoides acutangulus* (Piper, 1976), *Tephritis dilacerata* Loew (Berube,



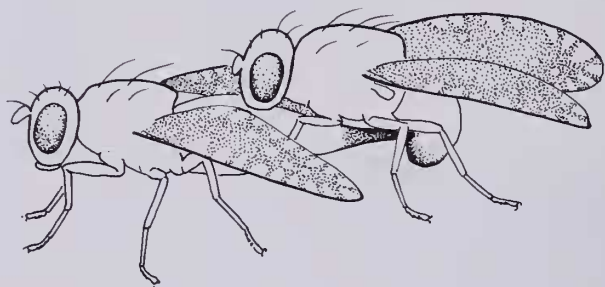
Figs. 1-4. *Euaresta bella* on *Ambrosia artemisiifolia*. 1. Female waving alternate wings while approaching a resting male. 2. Male performing the spread-winged display to an intruding male, in defense of its territory. 3 and 4. Females ovipositing through the floral involucre.

1978) and *T. stigmatica* (Coquillett) (Tauber and Toschi, 1965); it may be a general species recognition signal in *E. bella*.

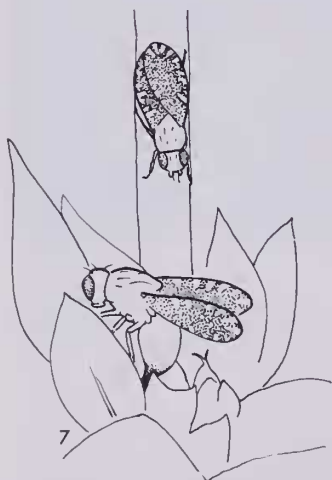
A behavior pattern peculiar to both sexes (but usually seen in males) of *E. bella* is a simultaneous horizontal spreading of both wings (Table 1: 3-5). The vertically tilted wings are spread out for several seconds while the fly turns toward another fly of either sex or another small insect. A conspecific fly may respond by similarly spreading its wings while facing the instigator (Fig. 2); the abdomen may vibrate. After approaching, one of the



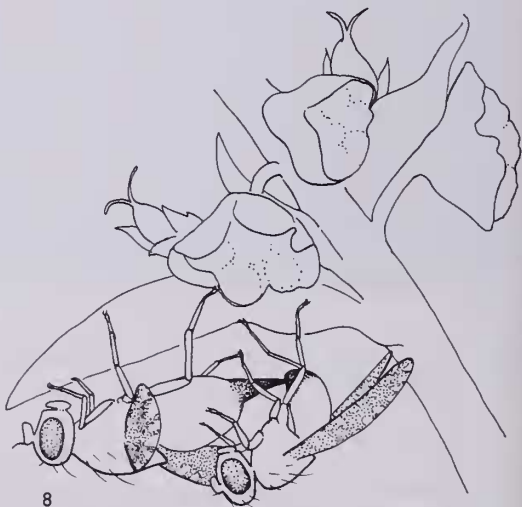
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Figs. 5-8. *Euaresta festiva* and *E. bella*, as drawn from color slides. 5. Proboscis contact or 'kissing' by male and female *E. festiva*. 6. Copulation of *E. festiva*. 7. Female *E. festiva* ovipositing, as male watches in precopulatory attitude. 8. Copulation of *E. bella*.

flies may butt the other with its head (Table 1: 5), or both flies may make contact with each other's proboscis (Table 1: 4); a female may extend her front feet in addition to her proboscis. Unlike *Drosophila* (Spieth, 1974), and *E. festiva*, this 'kissing' in *E. bella* is not only used for courtship, but appears to be related to territoriality, because one of the flies (usually not the initiator) abruptly leaves the area after kissing, butting, or wing spreading displays. Proboscis extension is usually initiated by males, but occasionally females approach other females in this way (20 ♂: 3 ♀-initiated). Butting and chasing other *E. bella* (including a mating pair) or other insects (gnats, small Hemiptera, beetles, ants), was performed by both sexes (17 ♂: 6 ♀). Nonreceptive females thus deterred male advances. Male *E. festiva*, before following females, extended their probosces to make contact with those of females (Fig. 5) in conjunction with abdomen vibration and wing flicking, as part of the courtship.

Rapid, repeated, simultaneous flicking (10/sec.) of both wings is characteristic only of males in both *E. bella* and *E. festiva* (Table 1: 7). Male *E. festiva* flicked their wings while orienting toward both sexes, while mating, and occasionally before the spread-winged display.

Lekking or male territoriality by male *E. festiva* and *E. bella* was common (Table 1: 8). This behavior pattern also occurs in male *Rhagoletis* (Christenson and Foote, 1960), *U. jaceana* (Varley, 1946), and *Valentibulla* spp. (Wangberg, 1978). Territories of male *E. bella*, on one or two leaves of the host, were about 7–10 cm sq., and appeared to be occupied by individual males for only a few hours (males were not marked for recognition); the same areas were usually not used the next day. The larger territories of male *E. festiva* are about 1 m sq.; males returned to their territories after flying away when they were disturbed by the observer. Male *E. bella* drove other insect species and other males from their territories by butting them or running at them with their probosces and wings extended. Wandering females were displayed to when they entered or approached male territories. The aggressiveness of males toward each other and toward nonreceptive females may be advantageous to the species, by aiding dispersal and subsequent oviposition in a larger number of plants. Female-female aggression, as in *Dacus dorsalis* Hendel (Christenson and Foote, 1960) also helps to disperse the population and avoid multiple ovipositions in the small *Ambrosia* fruits.

Male *E. festiva*, more often than male *E. bella*, were seen closely following females; their abdomens were ventrally curved (Table 1: 9, 10). These males kept their wings folded closely, one above the other, above their abdomens while following or observing females (Fig. 7); they waited 2–4 cm away while females completed probing or ovipositing in flowers before they moved closer and attempted to copulate from the rear. Although mating in

*E. festiva* is associated with oviposition, as in *T. dilacerata* (Berube, 1978), ovipositing females of *E. bella* were not noticeably attractive to males.

### Copulation and Oviposition

Mating in *E. festiva* occurred between 14:20 and 18:00 EDT; two copulations lasted 57 and 58 minutes (Fig. 6). Couples walked or flew and both sexes occasionally flicked their wings. In *E. bella*, mating occurred between 8:00 and 17:00 EDT, with most copulations about 16:00, when the flies generally were most active. Fifteen copulations lasted 20–60 minutes each (Fig. 8). Females walked, fed, performed the spread-winged display, and butted at nearby flies while mating; males occasionally flicked their wings.

Fecund females of *E. bella* and *E. festiva* wandered over the leaves and stems of their hosts, but female flowers in the upper half of the plants were most attractive to ovipositing flies. Before ovipositing or probing the flowers with the ovipositor, flies walked about over the flowers, and occasionally contacted them with their probosces. *E. festiva* characteristically stood above the female flowers while probing or ovipositing (Fig. 7). The ovipositor was inserted for 10 to 60 seconds; the shorter times being apparently probes, since eggs were not subsequently found, although the sides of the flowers' involucre and ovaries had been slit (brown slit marks, 0.3 to 0.7 mm long). In *E. bella*, such probing by the ovipositor slits numerous floral ovaries, causing necrosis and sterility of about 30% of the flowers that were probed, even when eggs were not laid. As described by Foote (1965), eggs of *E. bella* are partially inserted into young flowers at the edges of flower clusters or deposited on their surfaces; larvae then enter and totally destroy the developing seeds; eggs of *E. festiva* are placed inside the involucre against the seed coat (B. A. Foote, in litt.). During oviposition, *E. bella* typically penetrated flowers through the involucre from the side (Figs. 3 and 4), often with a rocking motion as the ovipositor was inserted. Probing and oviposition was seen between 13:30 and 17:05 EDT and each lasted 15 to 50 sec. Ovipositing females often probed several flowers in succession; one female probed six flowers in 15 minutes. Females usually groomed themselves after probing each flower.

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